NASA Facts

National Aeronautics and
Space Administration

Marshall Space Flight Center
Huntsville, Alabama 35812

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Marshall Space Flight Center: Reaching for the Stars, Reaping the Rewards on Earth

The Marshall Center Wernher von Braun Administrative Complex.

The mission of NASA's Marshall Space Flight Center in Huntsville, Ala., is twofold: Marshall is NASA's premier organization for development of space transportation and propulsion systems, as well as NASA's leader in microgravity research—unique scientific studies conducted in the near-weightlessness of space.

To witness the myriad daily activities at Marshall presents a visitor with a study in contrasts. Inside huge test structures, engineers scrutinize the performance of massive rockets—some of the most powerful locomotion systems ever devised—which generate forces measured in millions of pounds. In controlled laboratory environments just a short distance away, that special breed of scientists known as microgravity researchers monitor and try to control forces so tiny they are often measured in microns, or millionths of a meter.

These engineers and scientists are co-workers within the same organization, pursuing two primary goals of America's space program: bringing us closer than ever to realizing our shared vision of exploring the universe, and making life here on Earth more comfortable and more productive for all of humanity.

Reaching for the Stars

The Marshall Center is NASA's premier organization for space transportation. Marshall scientists and engineers are defining the cutting edge of technology that will dramatically reduce the costs of space travel, unlocking the doors to space development, exploration—and even tourism.

Today, it costs roughly $10,000 to put a pound of payload into space. But as the new millennium dawns, NASA is flight-testing advanced technology demonstrators developed at Marshall to reduce space launch costs to $1,000 per pound. Within a couple of decades, that cost is expected to dwindle to mere hundreds of dollars per pound—perhaps making space travel affordable even to ordinary folks.

Driving NASA's Flagship Vehicle

The Marshall Center provides and manages the Space Shuttle's propulsion elements: the main engines, the enormous solid-rocket boosters and the super-lightweight external fuel tank required for every Shuttle flight.

The Space Shuttle's main engine is considered by many to be the world's most sophisticated reusable rocket engine. Three liquid-fueled main engines produce nearly 1 million pounds of thrust—equivalent to the energy of 23 Hoover Dams.

The Space Shuttle.

The external tank provides liquid hydrogen and liquid oxygen to the main engines during the first eight-and-a-half minutes of Shuttle flight. At 154 feet long and more than 27 feet in diameter, the external tank is the single largest component of the Space Shuttle and the structural backbone of the system.

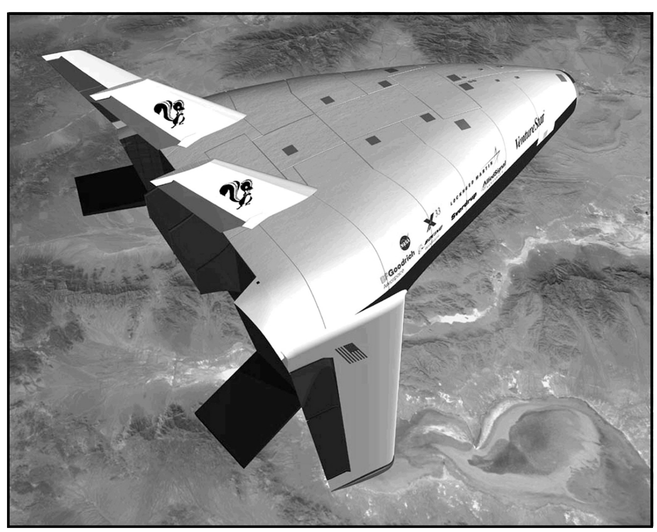
The Shuttle's solid-rocket boosters are the largest ever built and the first designed for refurbishment and reuse. Standing nearly 150 feet high, the twin boosters provide the majority of thrust for the first two minutes of flight—about 5.8 million pounds. That's equivalent to 44 million horsepower, or the combined power of 400,000 subcompact cars.

Reusable Rocket Planes: The Next Plateau

The Marshall Center manages a series of experimental, reusable launch vehicle demonstrators aimed at flight-testing a variety of technologies that are expected to increase safety and reliability and dramatically reduce launch costs.

X–33: Demonstrating Commercial Possibilities

The lightweight X–33, with its unmistakable wedge shape and revolutionary "linear aerospike" rocket engines, begins test flights in Summer 2000. Managed by the Marshall Center and built in partnership with Lockheed Martin Skunk Works in Palmdale, Calif., the vehicle can reach altitudes of 60 miles, traveling at up to 13 times the speed of sound. It takes off vertically, like a rocket, and lands horizontally, like an airplane. The success of the X–33 program will demonstrate the value of a full-scale, reusable commercial launch vehicle.



The X–33.

X–34: Making History at Mach 8

The X–34 is launched from beneath a modified L–1011 jetliner. Capable of flying eight times the speed of sound, the plane can reach altitudes of approximately 50 miles and lands on conventional runways.

The reusable Fastrac engine, designed and developed by Marshall engineers and built by NASA's industry partners, provides 60,000 pounds of thrust on powered X–34 flights. It is aimed at boosting payloads of up to 500 pounds.

The X–34.

X–37: Rocketing Into Orbit—Again and Again

Unlike the suborbital X–33 and X–34 demonstrators, the unpiloted X–37 Advanced Technology Vehicle—managed by the Marshall Center and developed in cooperation with the Boeing Co. of Seal Beach, Calif.—will make history as the first reusable demonstrator to fly in both orbital and reentry environments. It is expected to fly at speeds of up to 25 times the speed of sound.

About the length of two minivans, the space plane will be ferried into orbit by the Space Shuttle or an expendable rocket, where it can remain in orbit for up to 21 days, performing a variety of experiments before reentering the atmosphere and landing on a conventional runway.

The Future of X

Future-X is NASA's new series of advanced flight technologies slated to redefine the future of space transportation.

The Marshall Center oversees NASA's Future-X experiments, testing technologies in flight that could reduce space transportation costs. In December 1998, seven experiments were chosen for flight testing as part of the first series of Future-X experiments. Electric propulsion, integrated vehicle health monitoring systems and electrodynamic tethers that provide thrust without propellant are among the advanced concepts that will be tested in flight.

Propelling NASA's Center of Excellence

As NASA's lead center for Space Transportation Systems Development and the Agency's designated Center of Excellence for Space Propulsion, the Marshall Center manages several propulsion programs.

The Inertial Upper Stage is a two-stage, solid-rocket-propelled vehicle designed to place spacecraft in a high-Earth orbit or on escape trajectory for interplanetary missions.

Managed by Marshall, the Inertial Upper Stage was designated by NASA to launch the Galileo probe in 1989 on its six-year journey to Jupiter, where it studied the giant planet's atmosphere and climatic conditions. The Inertial Upper Stage earlier in 1989 saw the Magellan spacecraft safely to Venus for its planetary mapping expedition. In 1990, the Inertial Upper Stage propelled the Ulysses spacecraft on a journey out of the ecliptic plane to explore the Polar Regions of our sun. Most recently, it has put the Chandra X-ray Observatory in high-Earth orbit, where it has begun a five or more-year mission to document—through study of X-ray emissions—the violent history of the cosmos.

Inertial Upper Stage Rocket.

Marshall is developing the Interim Control Module, a backup or supplemental propulsion module for the International Space Station—the space research facility being assembled in orbit by the United States and 15 partner nations. Should a backup be needed for the main Russian Service Module, the Interim Control Module will be lifted to orbit by the Shuttle and docked with the Station to provide reboost and positioning capabilities during the initial years of Station construction.

The Space Station Propulsion Module will be constructed and fabricated by the Boeing Co. at Marshall Center facilities to provide long-term Station altitude and position propulsion. Capable of being refueled by the Space Shuttle every two years, the module is part of the automated collision-avoidance system to prevent the Station from crossing paths with potentially dangerous space debris.

The Marshall Center and Gencorp Aerojet of Sacramento, Calif., are developing the primary propulsion—the Deorbit Propulsion Stage—in support of the Space Station's Crew Return Vehicle, a "lifeboat" that will safely return the crew to Earth in emergency situations. The Deorbit Propulsion Stage will slow the Crew Return Vehicle and position it for atmospheric reentry and landing.

The prototype for the Crew Return Vehicle, the X–38, will be deployed from the Space Shuttle.

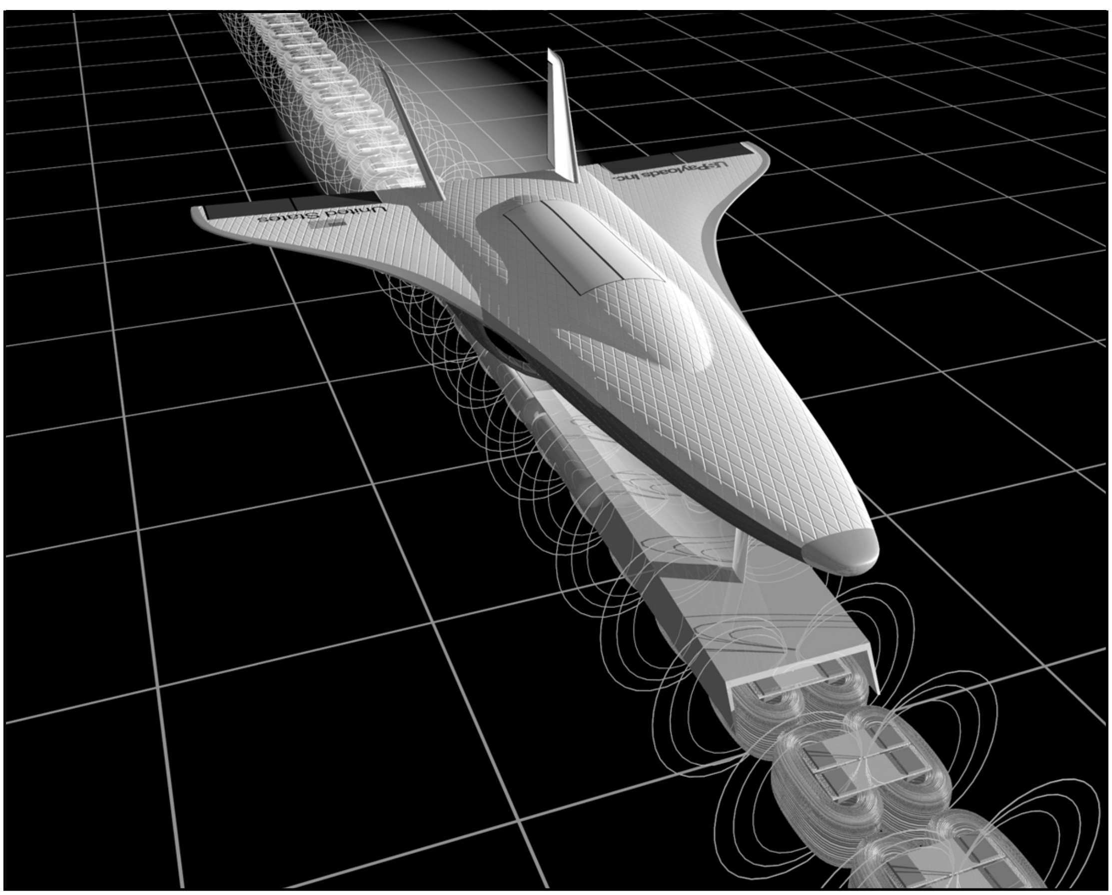
Tomorrow's Travel: From Science Fiction to Science Fact

The Marshall Center's Advanced Space Transportation Program is paving the highway to space, developing technologies that will dramatically increase safety and reduce the cost of getting to space.

Some of the technologies being explored to achieve this goal are simple, such as the inexpensive Fastrac engine that uses commercial, off-the-shelf parts. Some are radical—rocket engines that breathe oxygen from the air, laser beams that launch spacecraft, strong magnets that levitate and drive a space vehicle down a track. Still others are truly exotic—warp drive, wormholes and antimatter. In order for technologies to leap from the pages of today's science fiction to the journals of third-millennium space travelers, researchers are delving into breakthrough physics in search of solutions.

At the Marshall Center, engineers constantly push the technology envelope to uncover propulsion concepts that will open the space frontier for business and pleasure.

For more information on Marshall's space transportation programs, visit http://www.highway2space.com



Magnetic research.

Reaping the Rewards of Space Research

The Marshall Center's aggressive reach for the stars is intended to do more than advance humanity's exploration of the solar system and the universe beyond. New technologies derived from space science and research offer a wealth of benefits here on Earth, helping industry create new medicines and medical procedures, manufacturing processes, and electronics and communications breakthroughs that have already changed the lives of people all over the world.

Virtually no modern industry has been untouched by four decades of space research and development—and virtually every human life has benefited from the scientific endeavors that make up the second major mission of NASA and the Marshall Space Flight Center.

Weightless Environs, Weighty Research

Marshall is the lead NASA center working with a special breed of scientists who use microgravity—the unique, near-weightless environment of space—to conduct experiments that would be all but impossible to perform on Earth. Their work increases our understanding of biological, chemical and physical processes critical to space exploration and to a better way of life here on our planet.

Marshall's new Microgravity Development Laboratory is dedicated to helping investigators develop microgravity experiments—from conception in the lab to execution aboard the Space Shuttle or the International Space Station. Scientists can even initiate experiments by remote command from the Microgravity Development Laboratory, collecting data immediately as the research is performed in orbit.

NASA's Microgravity Research Program, managed at Marshall, helps investigators conduct research in five scientific fields: biotechnology, combustion science, fluid physics, fundamental physics and materials science. By gaining new understanding and developing new technologies in these areas, microgravity experiment results are leading to:

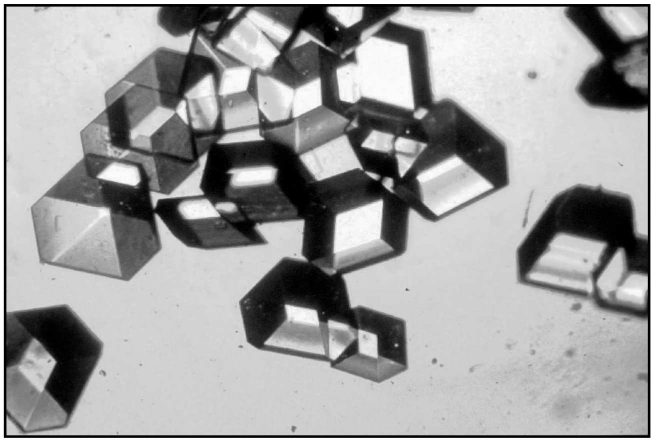
Astronauts conduct microgravity experiments aboard Space Shuttle.

• ***Improved health care on Earth:*** Researchers grow protein crystals and tissue cultures in space, contributing to important medical advances and development of disease-fighting drugs to combat heart disease, cancer, diabetes, AIDS, respiratory disease, hepatitis and rheumatoid arthritis.

• ***New alloys and composite materials:*** Advances in space may lead to stronger, lighter building materials—some with never-before-seen properties—as well as better aircraft and automobile engines and smaller, faster computer chips.

• ***New insight into combustion:*** Microgravity experiments are rewriting combustion science textbooks. In the future these experiments may lead to more efficient fuels, improved fire safety and a cleaner environment.

• ***New theories in physics:*** Understanding the way fluids and metals behave in space can help engineers better design our spacecraft and improve materials processing here on Earth. Fundamental and fluid physics experiments have enabled researchers to create models to better understand how weather forms, how earthquakes occur and the ways in which gravity affects almost everything we do.

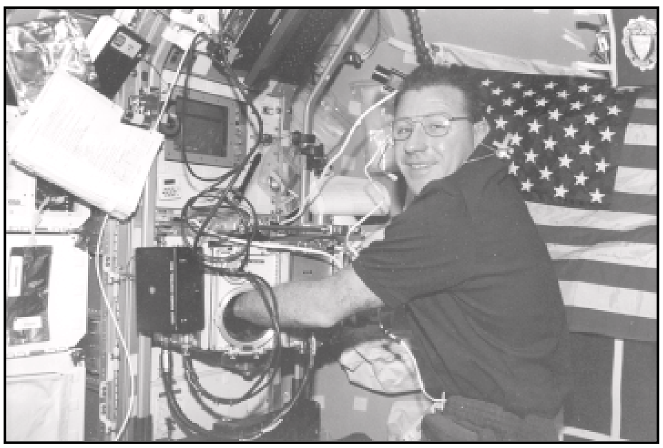


Microgravity research has enabled scientists to grow the largest insulin crystals ever studied.

• ***Opening the doors to commercial development of space:*** The Space Product Development Program managed at Marshall partners with industry to help advance commercial research. Working through 11 Commercial Space Centers, the program provides access to space and microgravity for industry directed and funded research designed to bring new products to market or improve existing products. Through this partnership, which has resulted in industry investment in the program of tens of millions of dollars, has come new or improved drugs and other advanced medical treatments, advanced materials, improved cast parts, and innovative agribusiness results.

Microgravity researchers are preparing experiments for flight aboard the International Space Station. Though completion of the Station is expected in 2004, the first microgravity experiments—those not requiring extended crew supervision or sizeable power resources—are scheduled for delivery to the orbiting science facility in 2000.

The size, duration and complexity of these experiments will increase dramatically when the primary U.S. research component—the Destiny Laboratory Module—is carried into space.



Astronaut Albert Sacco working with Microgravity Glovebox aboard Spacelab during STS–73.

Marshall also is designing, developing and testing the Microgravity Science Glovebox—an enclosed miniature laboratory to be permanently installed on the International Space Station. Wearing gloves, astronauts can insert their hands into the Glovebox to safely conduct otherwise hazardous experiments. The Glovebox will be used for biotechnology, combustion, fluid physics and materials science experiments.

Science in Space: A New Star on the Horizon

Today, the biggest cooperative science experiment in history is under way: Being assembled in orbit by the United States and 15 partner nations, the International Space Station orbits roughly 250 miles overhead, circling the globe at more than 17,500 mph. Scheduled for completion in 2004, the 470-ton "city in space" is wholly devoted to microgravity and other space sciences research.

From manufacturing and testing facilities to preparations for ongoing Space Station science research and science operations, the Marshall Space Flight Center is making significant contributions to NASA's International Space Station Program.

Major U.S. elements of the Space Station—the Unity connecting node, the Destiny Laboratory Module and the Station Airlock—were manufactured by the Boeing Co. at Marshall facilities. Teams of Marshall Space Flight Center engineers and technicians also conduct exhaustive preflight dynamic and structural tests of numerous Station elements, as well as thorough qualification testing of various Station components.

To eliminate the need to continuously resupply the Space Station crew with thousands of pounds of life-sustaining air and water, Marshall scientists are developing and testing the Environmental Control and Life Support System, a water recycling and oxygen generation system.

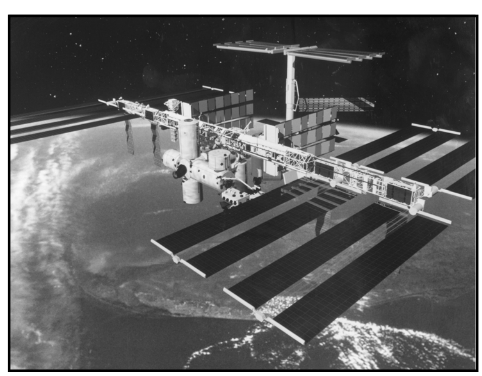
The work at Marshall will not end when the Space Station is operational. The Payload Operations Center at Marshall will lead all scientific experimentation on the Station, providing communications between researchers around the world and their orbiting experiments.

The Rigors of the New Frontier

Despite the seeming emptiness of its vast gulfs, space—the harshest environment humans have ever encountered—poses real threats to space travelers, their craft and their home world.

To provide for the safe exploration of space, engineers from the space agency, industry and academia work jointly on NASA's Space Environments and Effects Program, managed by the Marshall Center, to study potential threats. These range from meteors, solar radiation and electromagnetic forces to the gradual surface deterioration of spacecraft in flight.

One major objective is to lower operational costs and risks to spacecraft such as the International Space Station, where rotating crews will live and work for long periods of time. To help spacecraft withstand the challenges of the space environment, NASA researchers have conducted numerous



The International Space Station.

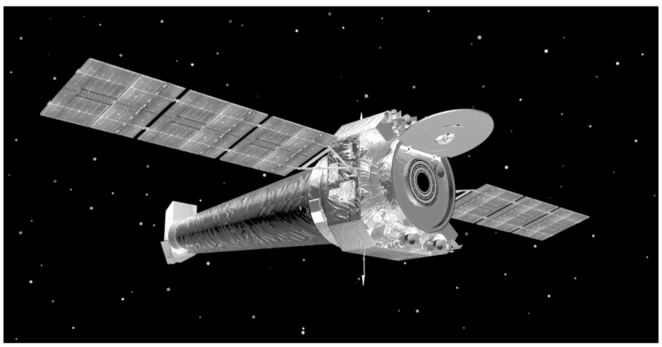
studies on the Russian space station Mir, attaching experiments to its exterior surfaces to scan them for signs of deterioration.

These tests have given investigators new understandings of thermal-control paints, chemical coatings, mirrors, optics and other materials—yielding vital information about the contaminants spacecraft confront in space.

Unlocking the Secrets of the Cosmos

In 1999, the Marshall Center celebrated the spectacular results of many years of hard work when the Chandra X-ray Observatory began one of the most auspicious scientific studies of our universe ever conducted.

With its first images already revealing exciting results, Chandra's mission for the next five or more years is to explore violent, high-temperature objects—comets, exploded stars, even black holes at the heart of far-off galaxies—in the largest physics laboratory ever created, the universe itself.



The Chandra X-ray Telescope.

Named for the late Indian-American astrophysicist and Nobel Laureate Dr. Subrahmanyan Chandrasekhar and managed by Marshall, the Chandra X-ray Observatory is the most powerful X-ray telescope ever built.

For the latest information about Chandra's mission—and images shot by the orbiting telescope—visit the Chandra Website at http://chandra.nasa.gov

Next–Generation Space Telescopes

Before we can reach for the stars, we must first see them.

Unwilling to rest on its laurels in the wake of the success of the Chandra X-ray Observatory, NASA and the Marshall Center are already looking ahead to the development and launch of even more advanced telescopes. These new instruments will be powerful enough and contain optics delicate enough to discern tiny, potentially Earth-like planets in distant solar systems.

The Marshall Center's new Space Optics Manufacturing Technology Center leads NASA's development of advanced, ultra-lightweight optics materials, fabrication technology, precise measurement standards and state-of-the-art testing facilities.

The center—which teams with industry, academia, and other government agencies in pursuit of its space optics goals—provides active support to key Marshall programs, including microgravity studies, space transportation projects and propulsion research. Potential applications for optics technology include Earth remote sensing, optical communications, solar power, and even spacecraft propulsion.

Elemental Discoveries: Water, Wind and Fire

NASA's Global Hydrology and Climate Center, managed by the Marshall Center in Huntsville, is the scientific powerhouse for climatology research in the Southeastern United States. The Global Hydrology Center and the university community are working together toward a future of improved hurricane and severe storm prediction, more reliable day-to-day weather forecasting and more effective urban planning.

Electrifying research is being conducted at the center. Since 1995, NASA lightning researchers have launched two imaging devices into space—the Optical Transient Detector and the Lightning Imaging Sensor—to gather and relay information to researchers on Earth about lightning and thunderstorm activity around the globe. These sensors are paving the way for a space-based lightning mapper. Capable of delivering continuous, global lightning information to forecasters within seconds, the mapper would prove invaluable for storm "nowcasting"—giving people anywhere in the world earlier warning of severe storms.

On another front, "heat hunters" at the Global Hydrology Center are striking back at the modern phenomenon known as the urban heat island. The concrete jungles of our large urban areas get significantly hotter than rural areas, forming pockets of high-temperature air over major cities. NASA's heat hunters are using thermal imaging technology to pinpoint these big-city hot spots, in hope of curbing the effects of the urban heat island. Researchers intend to show how the strategic placement of "urban forests" and reflective surfaces may help cool cities, cut pollution and reduce energy bills.

Photo by Bob Blankenship

Lightning research conducted at Marshall could provide earlier warning of severe storms.

A Brief History of the Marshall Center

Established in 1960 under the guidance of Dr. Wernher von Braun, the Marshall Center was responsible for the design and development of the Mercury-Redstone vehicle that in 1961 boosted America's first astronaut, Alan B. Shepard, into suborbital flight. Eight years later, Saturn rockets developed at Marshall took the first humans to the Moon and returned them safely to Earth.

The Marshall Center's contributions to the advancement of space travel have been matched by its diligence and dedication to furthering space science and microgravity research. In the 1970s, Marshall managed Skylab, the first crewed American space station, as well as Spacelab, the orbiting science laboratory launched by the United States and 10 partner nations. Marshall also was responsible for the Hubble Space Telescope, the space observatory that continues to make unprecedented scientific discoveries about our universe.

Facilities (FY98)

The Marshall Space Flight Center, covering 1,841 acres on Redstone Arsenal, an Army installation in Huntsville, Ala., is home to 157 buildings and 70 structures. The Center is served by 38 miles of pressurant and propellants pipelines, 1.45 million gallons of cryogenic storage capacity, 15 miles of steam and industrial water pipes and 189 miles of electrical cable. Marshall's replacement cost has been estimated to be $1.1 billion.

Employment (FY98)

The Marshall Center's employee base in Huntsville, Ala., includes 2,641 civil servants—2,561 of whom are permanent, full-time employees. Among this educated workforce, 1,439 employees hold bachelor's degrees, 522 hold master's degrees and 166 hold doctorate degrees. Marshall also employs more than 4,000 full-time support service contractors. Of these, approximately 1,300 are subcontractors and vendors. Marshall's workforce, however, extends well beyond the boundaries of Huntsville, including civil servants, contractors, subcontractors and vendors as shown below:

World-Class Facilities

The Marshall Center is home to dozens of engineering and science facilities designated as "World Class"—officially recognized by the global aerospace community as being among the best in the world. Among them are:

- The X-ray Calibration Facility, which simulates X-ray emissions from distant celestial objects for evaluating X-ray telescope mirrors, such as those at work in the Chandra X-ray Observatory.

- The Flight Robotics Laboratory, which identifies and verifies rendezvous and docking concepts and mechanisms, and simulates flight dynamics for guidance, navigation and control subsystems.

- The Space Shuttle Main Engine Hardware Simulation Laboratory, which evaluates avionics hardware, software and hydraulics control systems and validates the engine computer program prior to every flight or static firing.

- Contracts, Grants and Cooperative Agreements (FY99) Marshall manages 1,480 active contracts, grants and cooperative agreements valued at $36.7 billion, awarded in 48 states and the District of Columbia.

Budget by Program Area (FY 98, $s in Millions)

Program	$M	% of Total
Human Space Flight	$1,340	58.0%
Aero & Space Transportation Technology	413	18.0%
Space Sciences	264	11.0%
Institution	125	5.0%
NASA Communication	76	3.0%
Microgravity	64	3.0%
Earth Sciences	35	1.0%
Other	15	1.0%
Grand Total	$2,330	100.0%

NOTE: Civil service salaries (by rate) prorated to programs

SOURCE: Fiscal Year 1998 data—Fiscal Year 2000 budget to Congress

Marshall Expenditures and Jobs—FY98

State	$M	Workforce
Alabama	722.2	9,152.5
Arizona	9.6	131.7
California	568.2	6,205.3
Colorado	23.8	326.3
Connecticut	22.0	301.7
Florida	131.6	1,445.2
Illinois	33.1	454.0
Kansas	8.0	109.9
Louisiana	286.9	2,899.1
Maryland	13.0	180.1
Massachusetts	47.3	648.1
Minnesota	14.5	198.4
Mississippi	17.1	232.8
New Jersey	14.6	200.6
New York	11.5	157.5
Ohio	10.8	147.2
Tennessee	27.2	374.6
Texas	24.7	338.8
Utah	312.7	2,775.9
Virginia	24.2	331.1
Wisconsin	8.1	110.9
Other States	56.4	700.6
Foreign	18.6	255.2
Unidentified	27.1	250.6
Grand Total MSFC	2,433.1	27,928.1